

Planetary Science Division Update

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March 30, 2015

Presentation at PSS

Outline

- Mission events
- Passed FY15 Budget elements
- President's FY16 Budget
- Discovery and New Frontiers Status
- Mars Program Status
- Recent Europa Activities
- Community Challenge
- Responses to PSS findings

Planetary Science Missions Events

2014

- July – *Mars 2020* Rover instrument selection announcement * Completed
- August 6 – 2nd Year Anniversary of *Curiosity* Landing on Mars
- September 21 – *MAVEN* inserted in Mars orbit
- October 19 – Comet Siding Spring encountered Mars
- September – *Curiosity* arrives at Mt. Sharp
- November 12 – ESA's *Rosetta* mission lands on Comet Churyumov–Gerasimenko
- December 2/3 – Launch of *Hayabusa-2* to asteroid 1999 JU₃

2015

- March 6 – *Dawn* inserted into orbit around dwarf planet Ceres
- Late April – *MESSENGER* spacecraft impacts Mercury
- May – Europa instrument Step 1 selection
- July 14 – *New Horizons* flies through the Pluto system
- September – Discovery 2014 Step 1 selection

2016

- March – Launch of Mars missions *InSight* and ESA's *ExoMars Trace Gas Orbiter*
- March – Europa instrument Step 2 selection
- July – *Juno* inserted in Jupiter orbit
- July – ESA's *Bepi Colombo* launch to Mercury
- September – Discovery 2014 Step 2 selection
- September – *InSight* Mars landing
- September – Launch of Asteroid mission *OSIRIS – REx* to asteroid Bennu
- September – *Cassini* begins to orbit between Saturn's rings & planet

Planetary Budget

Passed FY15 Appropriations Bill

- Planetary Total Budget: \$1,438M
- \$255.8M for Planetary Science Research, including \$165.4M for Research and Analysis and \$40M for Near Earth Object Obs;
- \$255M for Discovery, including not less than \$25M for Future Discovery Missions;
- \$286M for New Frontiers, including not less than \$5M for Future New Frontiers Missions and \$224.8M for OSIRIS-REx;
- \$305M for Mars Exploration, including not less than \$100M for a Mars 2020 Rover that meets scientific objectives laid out in the most recent Planetary Science decadal survey;
- \$181M for Outer Planets, including not less than \$100M for a Jupiter Europa mission as described in the House report; and
- \$155M for Technology, including \$18M for technologies for the study and characterization of the surface and subsurface of Europa

President's FY16 Budget Request (\$M)

[-----Notional-----]

	FY15	FY16	FY17	FY18	FY19	FY20
Planetary Science	<u>\$1,437.8</u>	<u>\$1,361.2</u>	<u>\$1,420.1</u>	<u>\$1,458.0</u>	<u>\$1,502.4</u>	<u>\$1,527.8</u>
Science Research		276.3	282.0	292.0	291.7	285.7
Discovery		156.1	201.6	277.2	337.4	344.9
New Frontiers		259.0	124.0	81.5	85.7	137.8
Mars Exploration		411.9	539.3	561.3	531.5	464.2
Outer Planets		116.2	117.7	81.6	87.6	110.5
Technology		141.7	155.5	164.4	168.5	184.7

Planetary Budget Features: What's Changed

- Initiates formulation for a mission to Jupiter's moon Europa, to explore the most likely host of current life beyond Earth
- Releases the next New Frontiers AO in 2016
- Maintains Stirling technology development to support future radioisotope power systems
- Establishes the Planetary Missions Program Office at MSFC to manage Discovery, New Frontiers, **JUICE** and **Europa** flight projects
- **Lunar Reconnaissance Orbiter** and **Opportunity** rover not funded in 2016 budget
 - Will reassess condition/cost of maintaining LRO & Opportunity this summer
- Increase in funding for Near Earth Object Observation Program to accelerate hazardous asteroid detection and characterization

Planetary Budget Features: What's the Same

- Continues development of **InSight** and **OSIRIS-REx** missions for launches in 2016
- Continues development work on **STROFIO**, **MOMA**, and **JUICE** instruments in collaboration with ESA missions to Mercury, Mars and Jupiter, respectively, as well as on-going operations of **Rosetta** and **Mars Express** with ESA and planned operations of **Akatsuki** and **Hayabusa-2** with JAXA.
- Supports Planetary missions with mission operations and navigation tools, data archiving, and sample curation
- Continues supporting research and technology selections and awards, and maintains DOE capabilities to produce radioisotope power generators and the Plutonium-238 to fuel them

Discovery and New Frontiers Status

Discovery and New Frontiers

- ◆ Address high-priority science objectives in solar system exploration
- ◆ Opportunities for the science community to propose full investigations
- ◆ Fixed-price cost cap full and open competition missions
- ◆ Principal Investigator-led project



- ◆ Established in 1992
- ◆ **\$450M cap** per mission excluding launch vehicle and operations phase (FY15\$)
- ◆ Open science competition for all solar system objects, except for the Earth and Sun

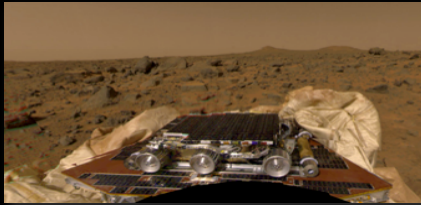


- ◆ Established in 2003
- ◆ **\$850M cap** per mission excluding launch vehicle and operations phase (FY15\$)
- ◆ Addresses high-priority investigations identified by the National Academy of Sciences

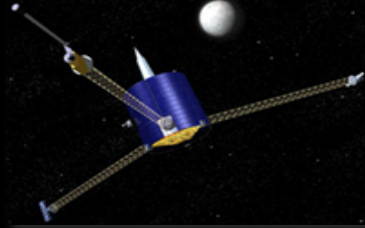
Discovery Program

Completed

**Mars evolution:
Mars Pathfinder (1996-1997)**



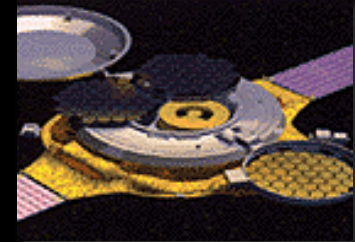
**Lunar formation:
Lunar Prospector (1998-1999)**



**NEO characteristics:
NEAR (1996-1999)**



**Solar wind sampling:
Genesis (2001-2004)**



Completed

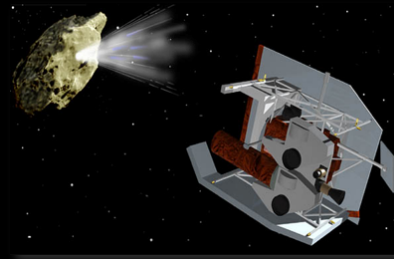
**Comet diversity:
CONTOUR (2002)**



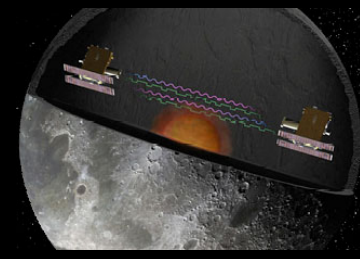
**Nature of dust/coma:
Stardust (1999-2011)**



**Comet internal structure:
Deep Impact (2005-2012)**

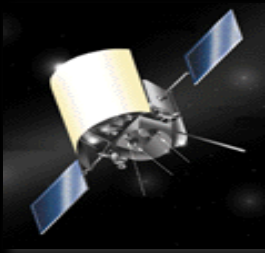


**Lunar Internal Structure
GRAIL (2011-2012)**

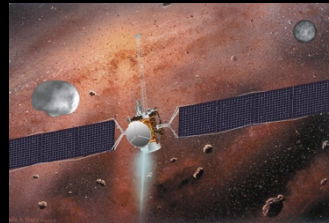


In Flight / In Development

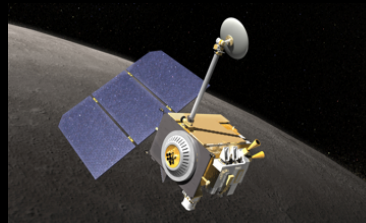
**Mercury environment:
MESSENGER (2004-2015)**



**Main-belt asteroids:
Dawn (2007-2016)**



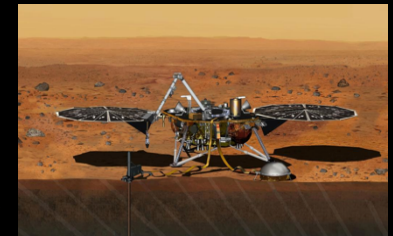
**Lunar surface:
LRO (2009-TBD)**



**ESA/Mercury Surface:
Strofiio (2016-TBD)**



**Mars Interior:
InSight (2016-TBD)**



Status of Discovery Program

Discovery 2014 - proposals in review for September Selection

Missions in Development

- InSight: Confirmation to begin ATLO on March 24, 2015
- Strofio: Delivered to SERENA Suite (ASI) for BepiColombo

Missions in Operation

- Dawn: In orbit around Ceres as of March 6

Missions in Extended Operations

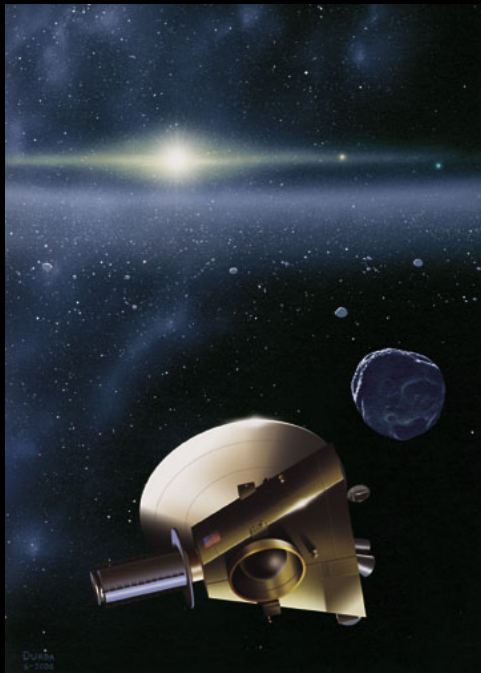
- MESSENGER: In low altitude science operations before impact with Mercury in April
- LRO: In stable elliptical orbit, passing low over the lunar south pole.

Future Opportunities – planning for 3-year mission cadence

New Frontiers Program

1st NF mission
New Horizons:

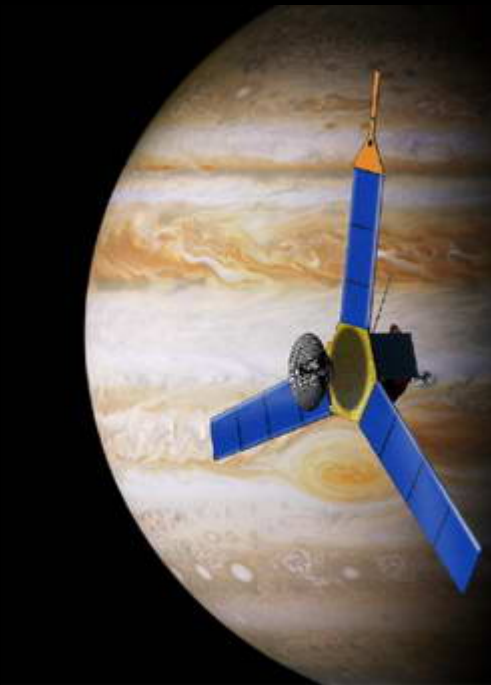
Pluto-Kuiper Belt



Launched January 2006
Arrives July 2015
PI: Alan Stern (SwRI-CO)

2nd NF mission
JUNO:

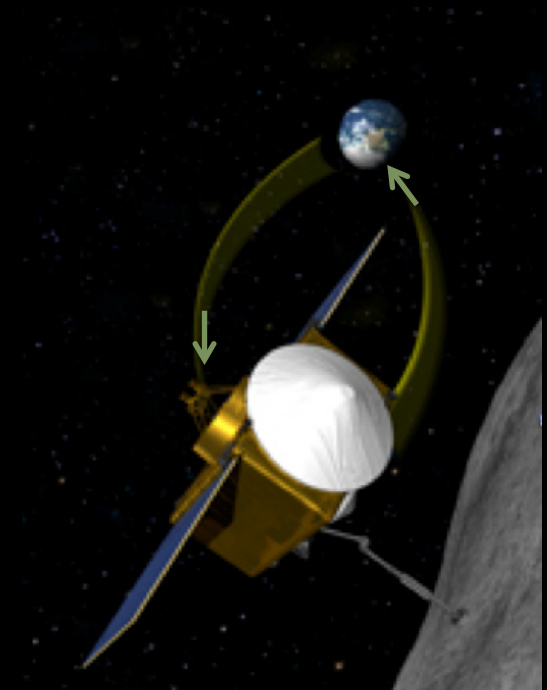
Jupiter Polar Orbiter



Launched August 2011
Arrives July 2016
PI: Scott Bolton (SwRI-TX)

3rd NF mission
OSIRIS-REx:

Asteroid Sample Return



To be launched: Sept. 2016
PI: Dante Lauretta (UA)

Status of New Frontiers Program

Next New Frontiers AO - to be released by end of Fiscal Year 2016

- New ROSES call for instrument/technology investments to prepare
- Candidate mission list and nuclear power sources under consideration

Missions in Development - OSIRIS REx

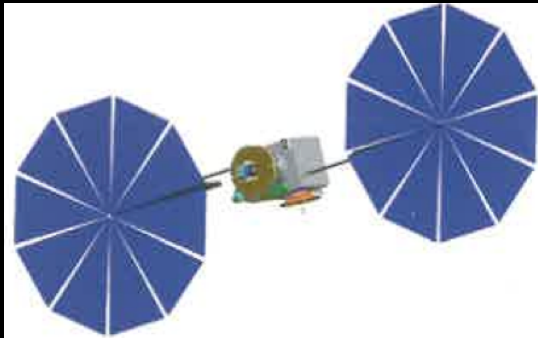
- Launch in Sept 2016 & encounter asteroid Bennu in Oct 2018.
- Operate at Bennu for over 400 days.
- Returns a sample in 2023 that scientists will study for decades with ever more capable instruments and techniques.

Missions in Operation

- New Horizons:
 - Spacecraft is 32 AU from the sun and <1 AU from Pluto
 - Pluto system encounter July 14, 2015
 - HST identified 2 KBO's beyond Pluto for potential extended mission
- Juno:
 - Spacecraft is 4.5 AU from the sun and 1.5 AU from Jupiter
 - Orbit insertion is July 4, 2016

New Frontiers #4 Focused Missions

Comet Surface Sample Return



Lunar South Pole Aitken Basin Sample Return



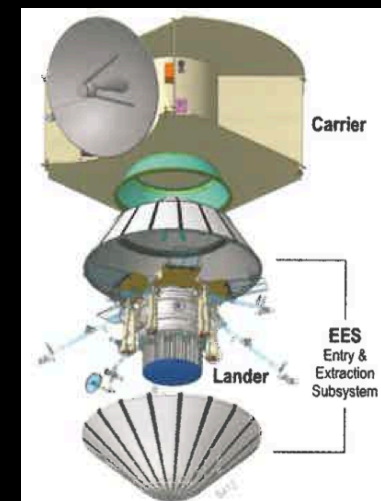
Trojan Tour & Rendezvous



Saturn Probes



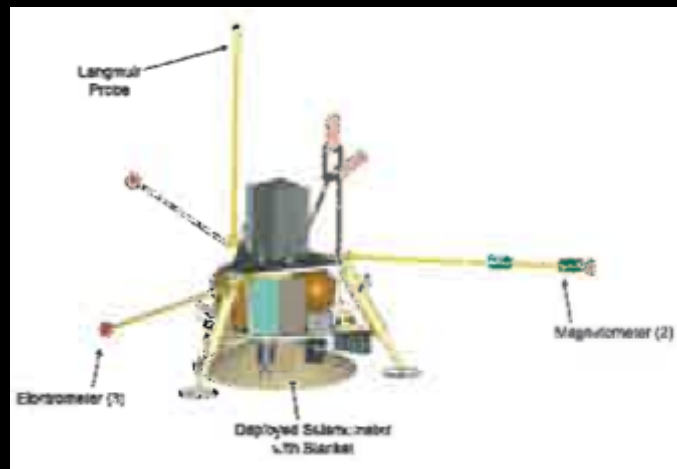
Venus In-Situ Explorer



New Frontiers #5 Focused Missions

- Added to the remaining list of candidates:

Lunar Geophysical Network



Io Observer



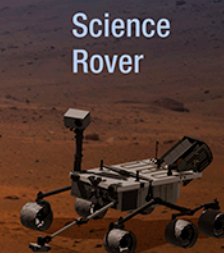
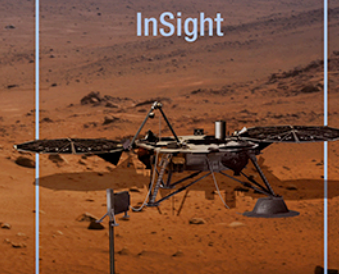
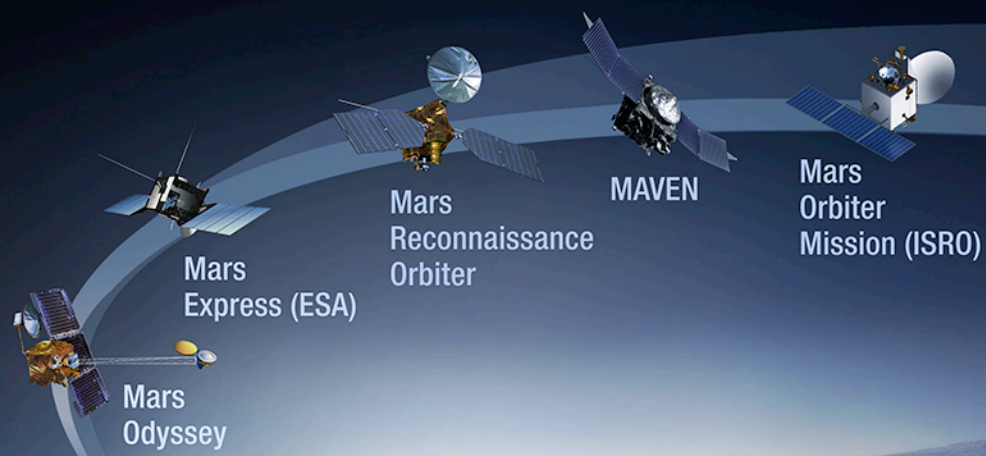
Mars Program Status

Operational 2001–2015

2016

2018

2020



Follow the Water

Explore Habitability

Seek Signs of Life

Prepare for Future Human Explorers

MARS-A-THON ROVER: OPPORTUNITY

First Marathon "Run"
on Another Planet

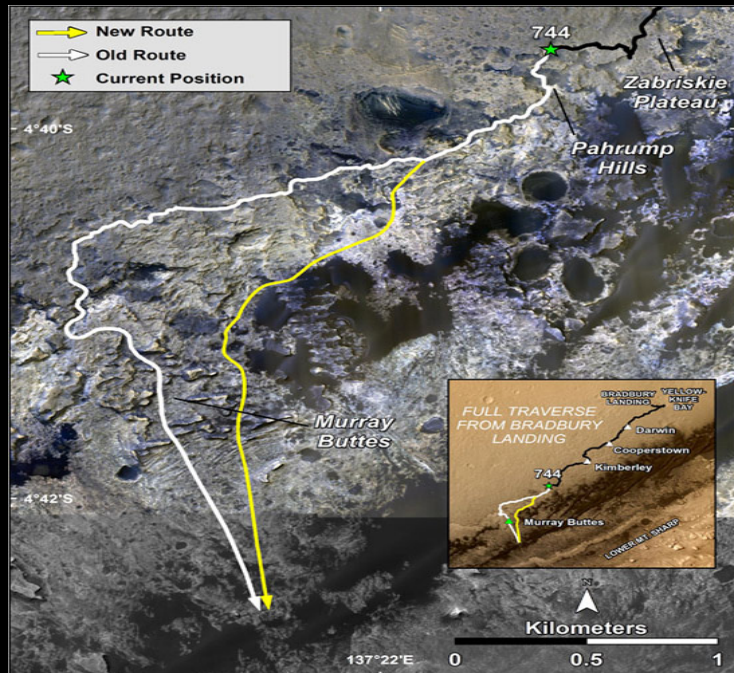
Distance: 26.2 miles

Time: 11 years, 2 months

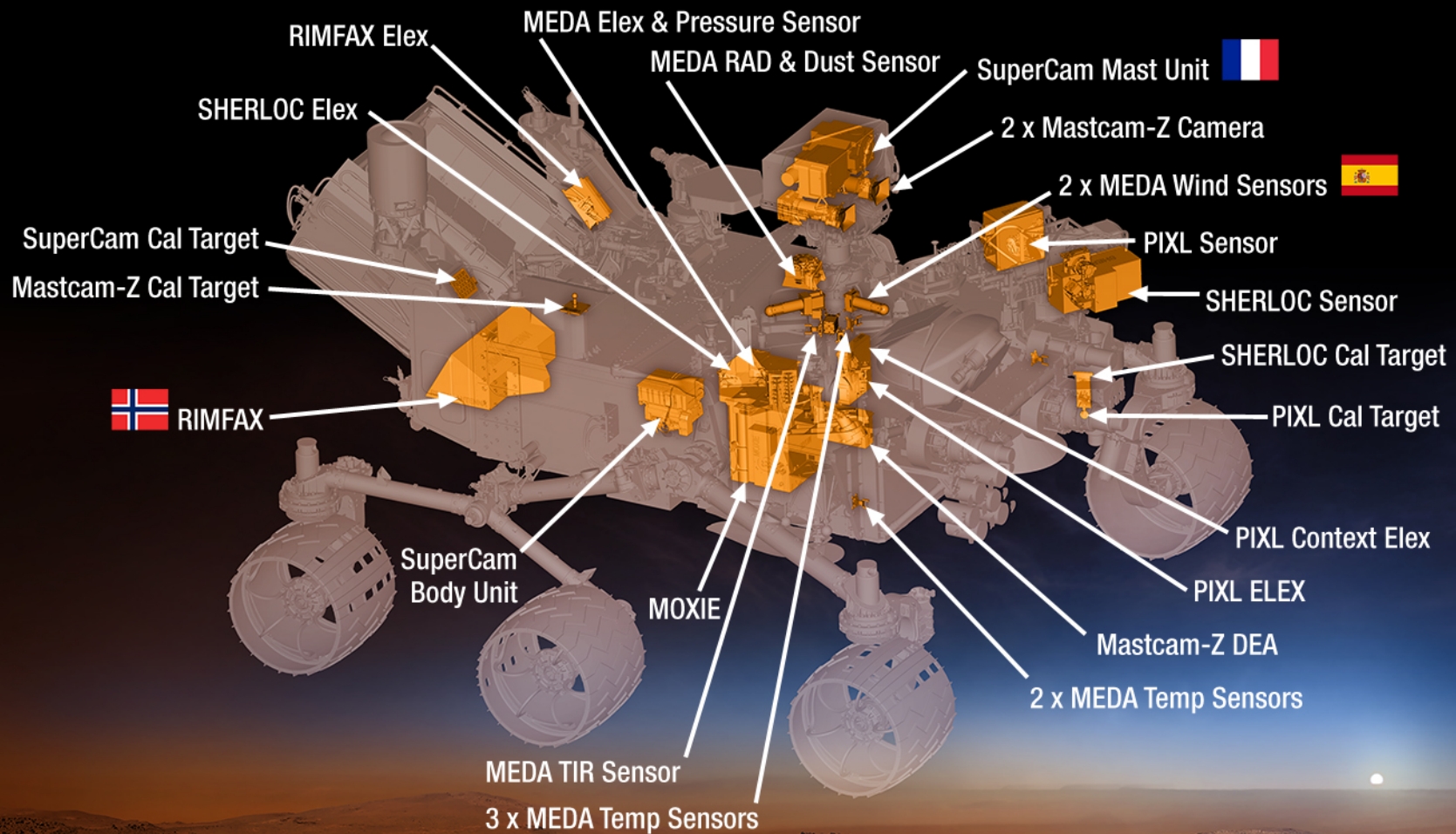
#JOURNEYTOMARS



Curiosity Arrives at Mt. Sharp



Mars 2020 Rover



Europa Activities

Recent Europa Activities

- Europa mission formulation in the President's FY16 Budget
- Instrument selections for Europa mission expected in May
 - Released SALMON 2 PEA in July 2014 to solicit instrument investigations for an unspecified Europa mission
 - 33 proposals evaluated
- Dedicated Hubble time to verify existence of Europa plumes
 - Not confirming their existence does not mean they don't exist. Variability factors are currently not understood.
- Workshop Feb. 18, 2015 with leading astrobiologists and Europa scientists to discuss how to look for life
 - Previous 'plume' workshop fully endorsed mission concept and payload
 - Identify 'best' instruments and mission concepts to maximize likelihood of detecting current life if it exists
- Europa mission formulation continues
 - Solar power system selected as baseline
 - Highly successful Mission Concept Review held
 - Key Decision Point A to kick off formulation in planning

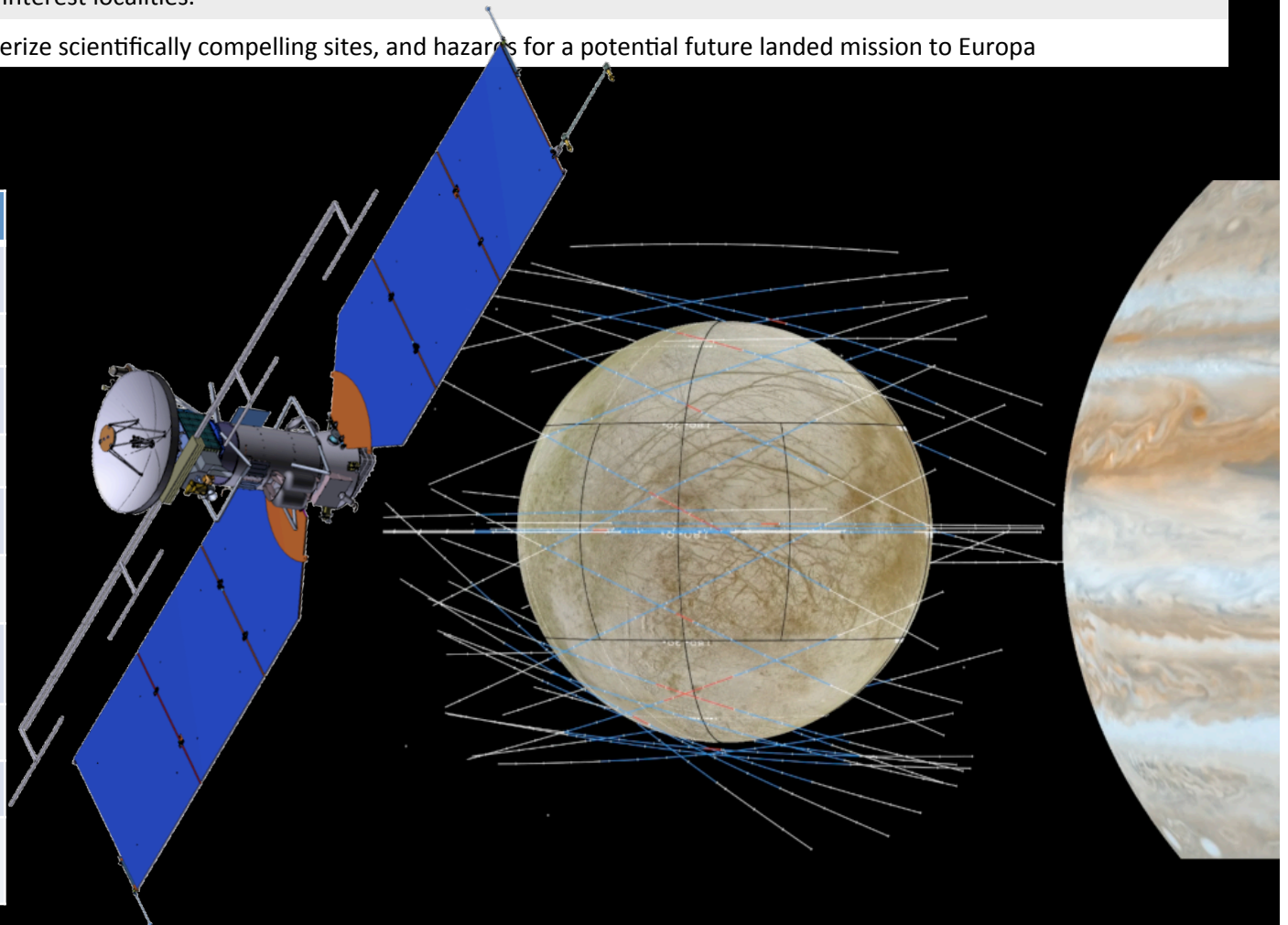
Europa Flyby Concept Overview

Science Objectives

Ice Shell & Ocean	Characterize the ice shell and any subsurface water, including their heterogeneity, and the nature of surface-ice-ocean exchange
Composition	Understand the habitability of Europa's ocean through composition and chemistry.
Geology	Understand the formation of surface features, including sites of recent or current activity, and characterize high science interest localities.
Recon	Characterize scientifically compelling sites, and hazards for a potential future landed mission to Europa

Model Payload

	<u>Instrument Type</u>
1	Ice Penetrating Radar
2	Shortwave Infrared Spectrometer
3	Topographical Imager
4	Neutral Mass Spectrometer
5	Reconnaissance Camera
6	Thermal Imager
7	Magnetometer
8	Langmuir Probe
9	Gravity Science



Community Challenge

Last Science Community Challenge

- Getting Community to take advantage of Astrophysics mission assets
- Web articles and News announcements
- JWST workshop at DPS 2014
- Increased number of planetary proposals to all
 - K2 workshop at DPS 2014 doubled the planetary proposals
 - Spitzer has 5x in planetary proposals than last cycle
- Chandra & SOFIA planetary usage also encouraged!

Astrophysics Division Telescopes

- HST surveys approved:
 - NH KBO (3 found) & Europa plumes
 - Hubble DD program to execute every year until the end of mission.
 - A total of 29 orbits/yr for Cycles 22-24, 41 orbits per Cycle thereafter.
 - Two global maps each for Jupiter, Uranus, Neptune and Saturn (starting after end of Cassini).
- More planetary proposals to HST are encouraged!

Next Science Community Challenge!

- 2015 will be a great year for planetary science
- Ceres and Pluto will be observed up close!
- Anticipate tremendous public interest
- PSD CHALLENGE:
 - Learn about these events – be knowledgeable
 - Take every opportunity to discuss with the public
 - When giving public talks always discuss D & NH using material posted
 - Be the local community expert
- Approved project material for D & NH posted on SBAG & OPAG websites
 - <http://www.lpi.usra.edu/sbag/>
 - <http://www.lpi.usra.edu/opag/>

PSS Findings

PSS Findings

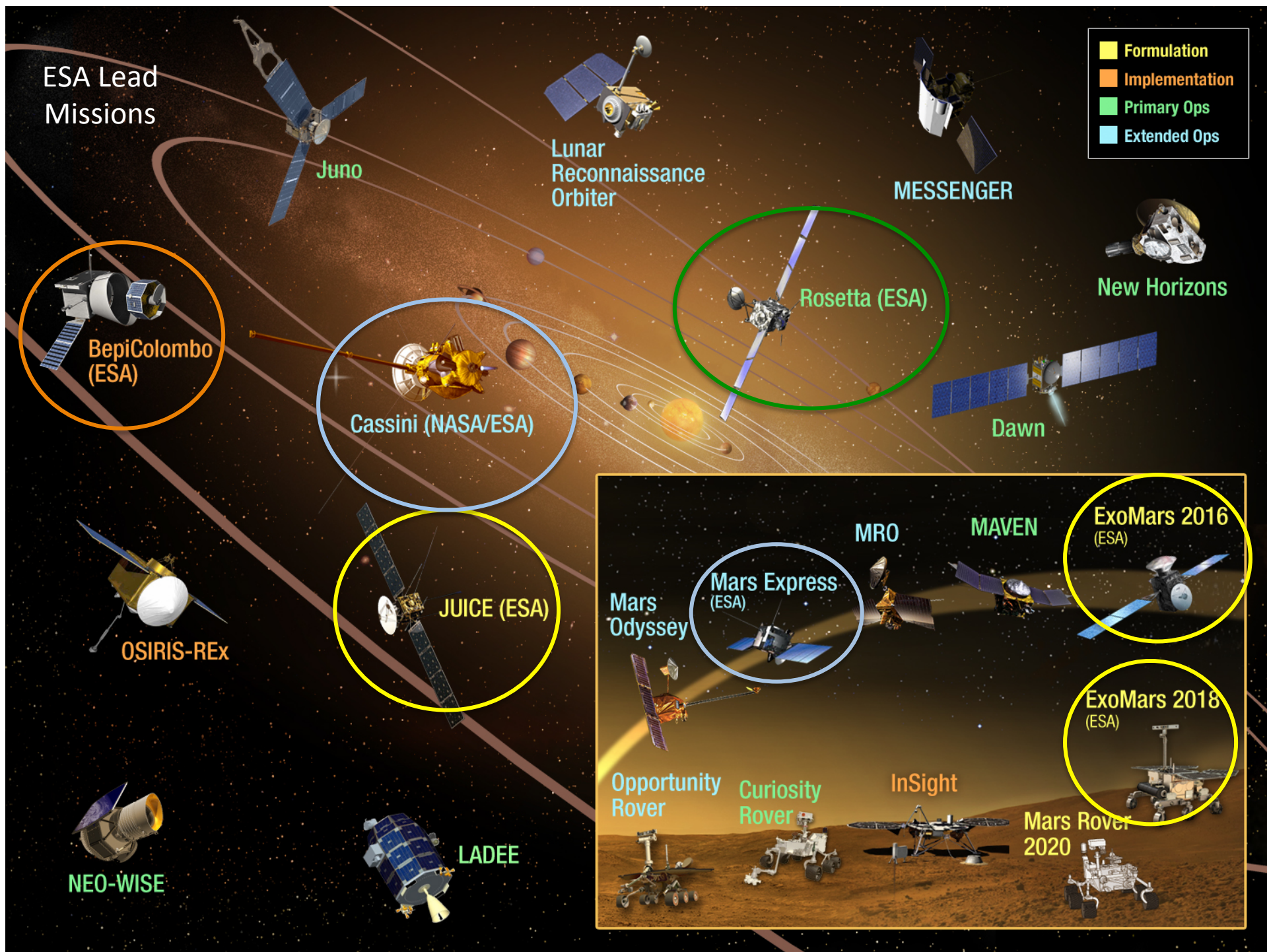
1. Establish formal representation for planetary cartography and geological mapping on PSS – [Rall](#)
2. Establish metrics and guidelines for applying programmatic balance to selection decisions in the R&A program – [Rall](#)
3. Make information available on the results (redacted as necessary) of the RFI for \$1B Europa mission – [JG](#)
4. Review & update charters for the joint HEOMD/SMD assessment groups (LEAG, SBAG, MEPAG) – [OBE](#) - [discuss new community input approaches](#)
5. Provide guidance regarding possibilities of responding to foreign mission opportunities – [JG](#)

#3. RFI Results for \$1B Europa mission

Europa Mission Concepts for < \$1B

- In 2014, NASA issued an RFI for complete mission concepts for exploring Europa at less than \$1B (FY\$15, excluding launch vehicle), to see if sufficient science progress would be possible for smaller than flagship missions
 - Assessed on ability to meet the majority of the five Decadal Survey science goals, including characterizing scientifically compelling sites for a potential future lander mission, while dealing with radiation & planetary protection
- Six responses received:
 - Independent costs estimates by Aerospace Corp. exceeded respondents' estimates by up to 200%
 - The cost for required technology development was generally not included in proposed estimates
 - Inadequate budgets for operations phase
- Missions close to the \$1B target minimally addressed a fraction of the Decadal Survey science, required follow on missions, and included risky technology developments. Missions that tried to address even half of the objectives approached \$2B (independent estimate for concept).

#5. Foreign Missions Opportunities



ESA

- ✓ Rosetta mission (3 full instruments, part of another)



- ALICE, MIRO, and IES

dynamics of comet C-G: how it develops its coma and tails, and how its chemicals interact with each other, and with radiation and the solar wind

- Significant portion of the electronics package for another instrument, ROSINA

- ✓ BepiColombo mission (1 instrument in the Italian Space Agency's instrument suite)

- ✓ Jupiter Icy Moon Explorer (JUpiter ICy moons Explorer) mission (1 instrument and parts of two others)

- ✓ Mars Express mission



- ASPERA-3
- MARSIS – With the Italian Space Agency
- Radio relay systems to make sure that different spacecraft operate together
- Hardware contribution to the energetic neutral atoms analyzer instrument
- Backup tracking support from DSN during critical mission phases

- ✓ Orbit-ground communications package on the Trace Gas Orbiter (to be launched in 2016)

- ✓ A part of the DLR/Mars Organic Molecule Analyzer instruments going onboard the ExoMars Rover (to be launched in 2018).

ESA

✓ M4

- August 2014 – ESA released its call for proposals in the medium-sized mission class (referred to as M4) as part of its Cosmic Vision program.
- Once again, ESA has been just tremendous in welcoming possible cooperative proposals with NASA.
- To ensure NASA's knowledge and attention in this opportunity, ESA requested a statement of interest from NASA to be part of the submitted proposal.
- September 9th, 2014 – Announcement to the planetary science proposing community through delineating how to obtain a NASA/PSD statement of interest from me.
- "Proposers desiring such a letter must submit to NASA a brief description of
 1. mission concept contemplated,
 2. relevance of its science objectives to established NASA planetary science objectives,
 3. contemplated U.S. involvement in the mission to be proposed and,
 4. how the U.S. contribution is unique and mission enabling."
- Based on this process I have delivered several statements of interest to ESA to its M4
- Call that closed on January 15th

JAXA

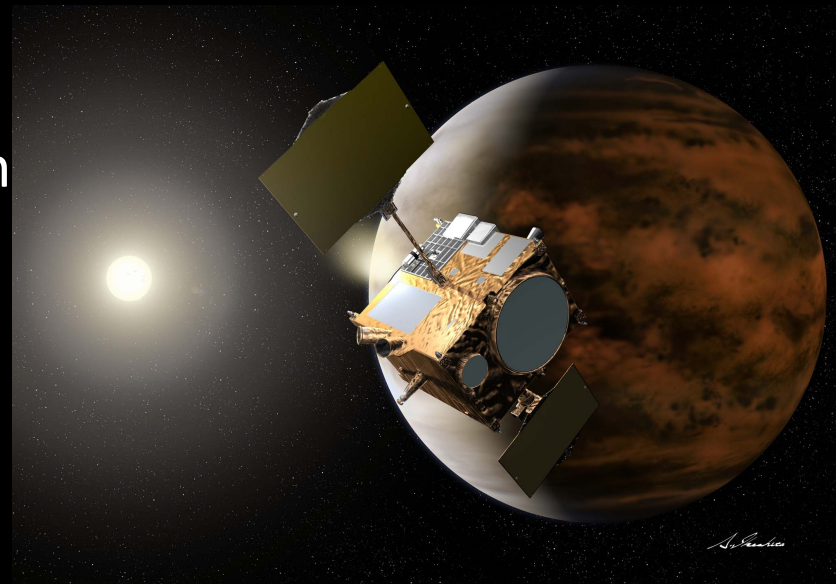
Asteroid Explorer HAYABUSA

- 1999JU3
- 10% Acquired Samples
- Participating Scientists



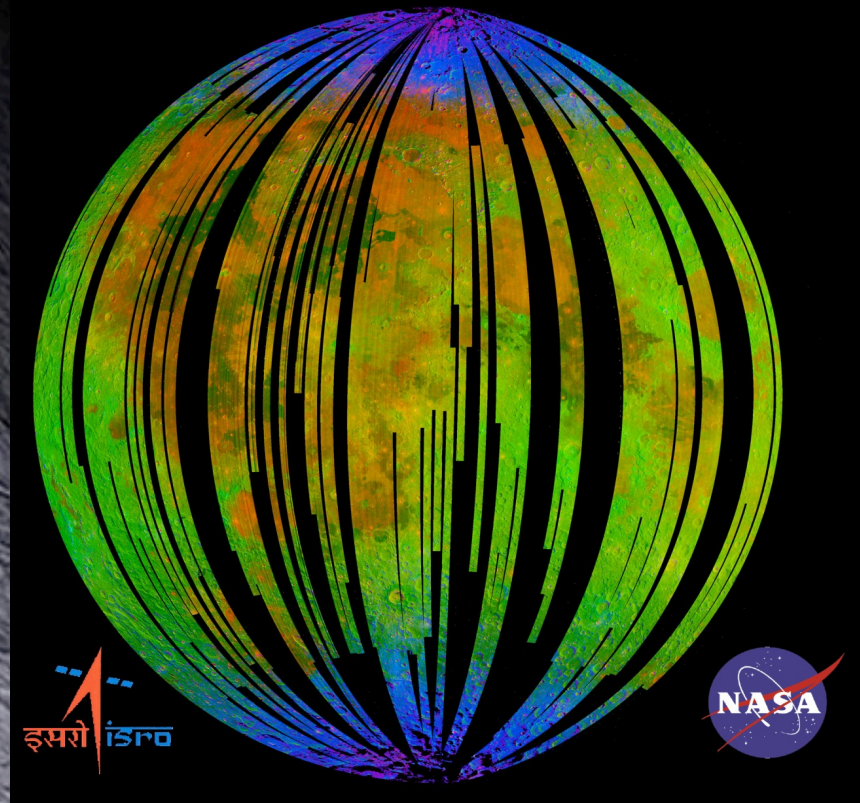
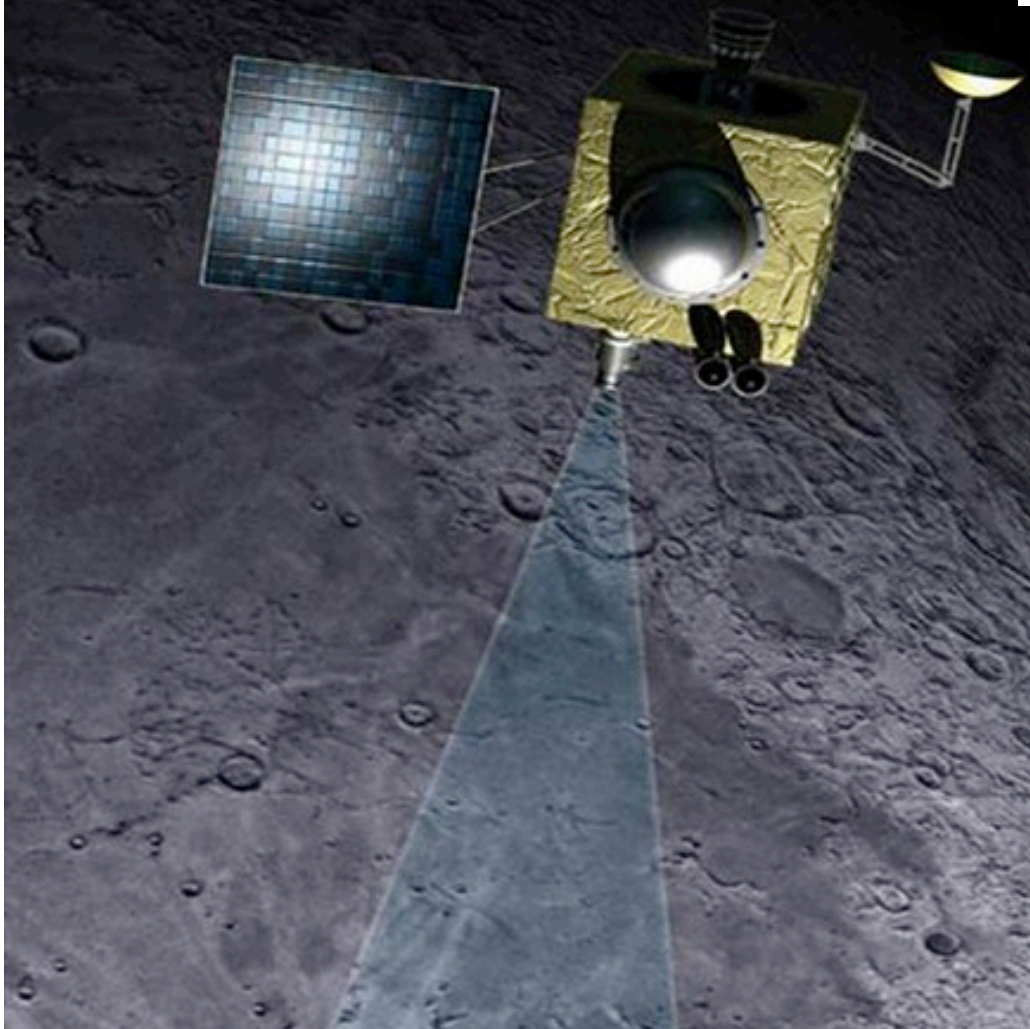
Venus Climate Orbiter AKATSUKI

- Deep Space Tracking and Navigation
- Data Analysis
- Long Term Data Archiving
- Participating Scientists



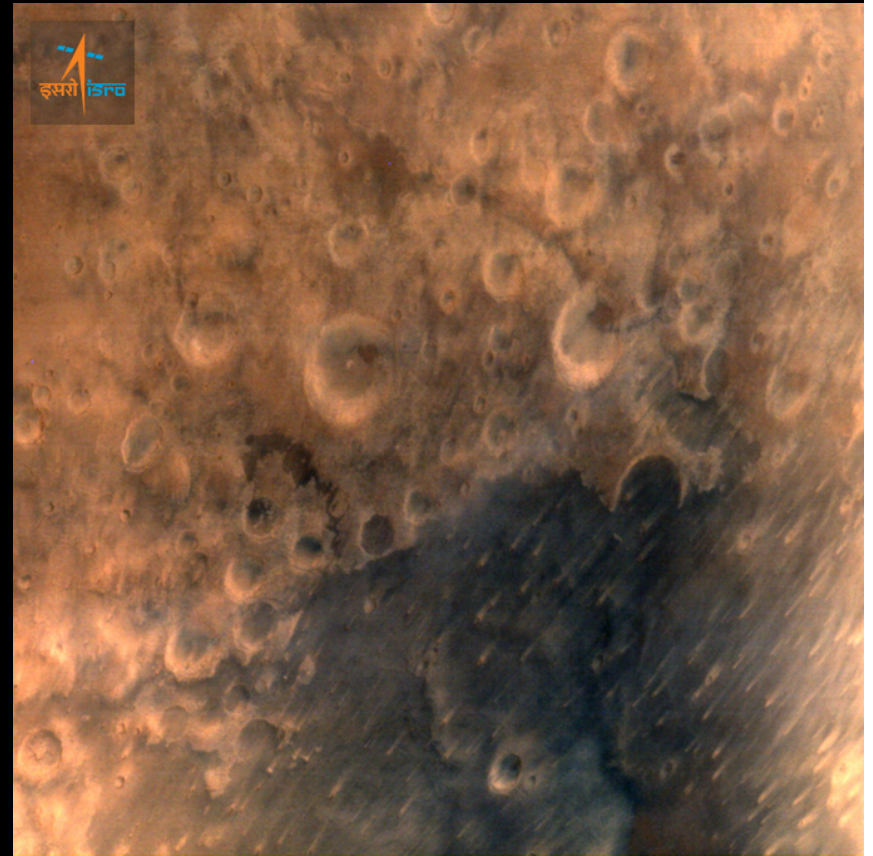
Indian Space Research Organization (ISRO)

**Moon Mineralogy
Mapper**



NASA & ISRO

- In Sept 2014, ISRO & NASA officially signed a charter for a Mars Working Group
 - Find ways to collaborate on currently operating Mars missions
 - Explore the possibilities for enhanced cooperation between the two countries on future Mars missions
- NASA wants to partner with ISRO on their next Mars mission



Questions?

